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Four Independent Approaches to Developing Sediment Quality Criteria Yield Similar Values for Model Contaminants

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P.M. Chapman, R.C. Barrick, J.M. Neff, R.C. Swartz

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Hazard Assessment

Short Communication

FOUR INDEPENDENT APPROACHES TO DEVELOPING SEDIMENT QUALITY CRITERIA YIELD SIMILAR VALUES FOR MODEL CONTAMINANTS

PETER M. CHAPMAN*
E.V.S. Consultants, N. Vancouver, British Columbia V7P 2R4, Canada

ROBERT C. BARRICK
Tetra Tech, Inc., Suite 100, Bellevue, Washington 98005

JERRY M. NEFF
Battelle, New England, Marine Research Laboratories, Duxbury, Maine 02332

RICHARD C. SWARTZ
U.S. Environmental Protection Agency, Mark O. Hatfield Marine Science Center, Newport, Oregon 97365

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Abstract—Separate approaches to determining marine sediment quality criteria yielded similar values for three contaminants. These values, including concentrations at or below which biological effects have been shown to be minimal and lowest concentrations at which biological effects have been shown to occur, range from (dry weight sediment): lead, 50 to 300 μg/g (ppm); polyaromatic hydrocarbons, 2.0 to 12.0 μg/g; polychlorinated biphenyls, 0.06 to 0.13 μg/g.

Keywords—Sediment quality criteria Lead Polyaromatic hydrocarbons Polychlorinated biphenyls

INTRODUCTION

At the Seventh Annual Meeting of the Society of Environmental Toxicology and Chemistry (November, 1986), a platform session was organized by C. Cowan (Battelle) entitled "Sediment Quality Criteria Development in Support of Environmental Protection." During the course of this session we each presented information on our respective approaches to developing sediment quality criteria. Each of these approaches, although pursued independently, involved relating bulk sediment chemistry to biological effects (field and/or laboratory). After the presentations, we realized that these values were surprisingly similar. These similarities are noteworthy and are reported herein.

METHODS

The sediment quality triad [1] provides a broad-scale approach to developing sediment quality criteria. The triad is based on the assumption that the biological responses observed in sediment bioassays and in situ studies are a function of the concentration of certain chemicals sorbed to the study-area sediment. The triad values were based on bulk sediment chemistry, sediment bioassay, and bottomfish abnormality data for Puget Sound (Washington State).

The Screening Level Concentration (SLC) approach [2] estimates the highest concentration of a particular sediment contaminant that can be tolerated by approximately 95% of benthic infaunal species. Calculations are based on a graphic plot and cumulative frequency distribution of species presence versus concentration of particular chemical contaminants. The SLC values are based on synoptic bulk sediment chemistry and benthic infaunal community data for parts of Puget Sound, and the New York and Southern California Bights.

The Apparent Effects Threshold (AET) approach (R. Barrick, H. Beller, T. Ginn and S. Becker. Apparent effects thresholds (AET): Evaluation as a tool for sediment quality management, in preparation) identifies concentrations of con-

*To whom correspondence may be addressed.

taminants that are associated exclusively with sediments that exhibit statistically significant biological effects (relative to reference conditions). The AET values were based on synoptic bulk sediment chemistry, sediment bioassay, and benthic infaunal community data for Puget Sound, and used different data sets than the triad.

Laboratory sediment bioassay tests were conducted with the phoxocephalid amphipod, *Rhepoxynius abronius*, to determine the toxicity of creosote-contaminated sediment from Eagle Harbor, Washington State [3]. Test sediment was mixed with reference sediment from Yaquina Bay, Oregon, and the 10-d LC50 of Eagle Harbor sediment was calculated by probit analysis to be 660 μg/g, wet weight. Thirteen polyaromatic hydrocarbons (PAHs) were analyzed in the sediment mixtures and the concentration at the 10-d LC50 was calculated by interpolation. A no-effect concentration for acute toxicity of total PAH was estimated as the 10-d LC01, from probit analysis.

RESULTS AND DISCUSSION

A number of studies are currently underway that attempt to develop sediment quality criteria. Four of these approaches, the triad, SLC, AET, and laboratory studies, are based on laboratory and/or field biological effects data.

Comparative values are presented in Table 1 for three model contaminants using the above four approaches, and are compared to concentrations of these contaminants shown to be toxic by Chapman et al. [4] in San Francisco Bay. The data from San Francisco Bay are not included in calculations of the other values, and hence represent a comparison between predicted and actual values. Biological effects represented by Table 1 values encompass a wide range of endpoints, including liver tumors in bottomfish; lethal, sublethal, and genotoxic laboratory bioassay responses; and significant changes in benthic infaunal community composition.

The partitioning of sediment contaminants into dissolved and particulate-bound fractions complicates development of sediment quality criteria. However, the similarities reported herein suggest that we may be able, within a reasonably tight range (e.g., less than an order of magnitude), to converge on appropriate sediment quality criteria which can be widely applied and which are supported by the burden of available biological effects data. We plan further independent and cooperative studies to determine the ultimate applicability of these approaches and values, including the relative significance of different sediment characteristics, biological responses, and methods of calculating the criteria.

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Table 1. Comparison of values obtained for three contaminants by four separate approaches to developing sediment quality criteria, and bioeffects data from San Francisco Bay

Chemical contaminants	No or minimal biological effects at or below these values[a]			Significant biological effects at or above these values[a]	Significant biological effects determined in San Francisco Bay at these minimum values[a]
	Triad	SLC[b]	Laboratory studies	AET	
Pb	50	—[c]	—	300	130
PAH[d]	3.8	7.6	2.0	5.2; 12.0	9.5
PCBs[e]	0.1	0.06	—	0.13	0.16

[a]All concentrations expressed as μg/g dry weight of sediment.
[b]Dry weight concentrations calculated from organic carbon normalized values assuming 2% organic carbon content.
[c]No data.
[d]Polyaromatic hydrocarbons. Triad = nine 4–6-ring PAHs; SLC = estimate for ten 4–6-ring PAHs; laboratory studies = thirteen 1–6-ring PAHs; AET = first value is for six 2–3-ring PAHs, second value is for ten 4–6-ring PAHs, San Francisco Bay = eighteen 1–6-ring PAHs.
[e]Total polychlorinated biphenyls.

Business Center, Alexandria, and then by A. Nilsson (E.V.S. Consultants).

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